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(54) Vehicle motor switching apparatus.

(57) There is provided a vehicle motor switching apparatus having an armature coil, a series circuit including a series coil and connecting the armature coil and a battery and a shunt coil, comprising a switch for connecting the shunt coil to the series circuit in parallel to the armature coil to set up the motor as a compound-wound motor when the shunt coil is connected to the series circuit, while set up the motor as a series motor when disconnected therefrom. The apparatus further comprises a switch for disconnecting the series coil from the series circuit to set up the motor as a shunt motor when the shunt coil is connected to the series circuit and the series circuit is disconnncted therefrom.

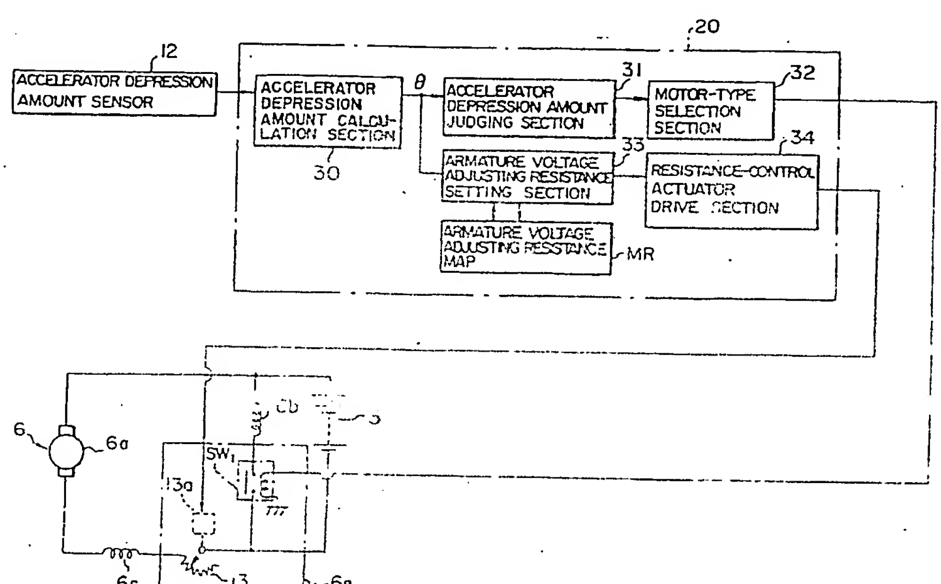


FIG. 3

VEHICLE MOTOR SWITCHING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to a vehicle motor switching apparatus for selecting a type of a vehicle motor among a series motor, a compound-wound motor and a shunt motor.

A vehicle motor is mostly driven by a battery installed in a vehicle, particularly an electric vehicle which has been developed for being free from oil resources and less pollution. Control of such a motor is one of the important factors in determining the vehicle performance.

The Japanese Utility Model Publication No. 1983(58)-21284 discloses such motor control. The control apparatus disclosed therein comprises a feeder circuit including a controller for adjusting a voltage or a current applied to a motor in response to an amount of depression of an accelerator.

Also, the apparatus comprises a brake circuit for braking the motor by short-circuiting two terminals of the motor and a switch interlocked by the accelerator for switching the two circuits.

The feeder circuit is driven to rotate the motor when the accelerator is depressed. On the other hand, the brake circuit is driven to brake the motor when the accelerator is released.

As is already known, a motor driven by means of a d.c. current from a battery is roughly classified into a series motor, a compound-wound motor and a shunt motor according to a wiring configuration of coils for exciting field poles.

Those motors are selectively used for their usage. However, only one type of a motor is sometimes not sufficient for a vehicle such as an electric vehicle which should be operated at various travelling conditions.

The series motor produces a large starting torque and excellent starting acceleration but also has a large speed variation and increases an engine speed greatly as a load torque to the motor is made small.

On the other hand, the shunt motor has a low speed variation or stable engine speed even if a load torque varies but also has relatively a small speed control region when a load is connected thereto.

Furthermore, the compound-wound motor has characteristics intermediate between the series motor and the shunt motor and a slow response to the change of the operating state.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an apparatus which swiches a type of a vehicle motor according to travelling condition to obtain best motor characteristics so as to improve vehicle performance.

According to the present invention, there is provided a vehicle motor switching apparatus having an armature coil, a series circuit including a series coil and connecting the amature coil and a battery and a shunt coil, comprising a switch for connecting the shunt coil to the series circuit in parallel to the armature coil to set up the motor as a compound-wound motor when the shunt coil is connected to the series circuit, while set up the motor as a series motor when disconnected therefrom.

The apparatus further comprises a switch for disconnecting the series coil from the series circuit to set up the motor as a shunt motor when the shunt coil is connected to the series circuit and the series circuit is disconnected therefrom.

The other objects and features of this invention will become understood from the following description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the configuration of an electric vehicle;
FIG. 2 shows a preferred embodiment of a control system according to the present invention;
FIG. 3 shows a functional block diagram of the control system shown in FIG. 2;
FIG. 4 shows the characteristics of each type of a motor;
FIG. 5 is a graph showing the relationship between an accelerator depression amount θ and an armature voltage adjusting resistance R;
FIG. 6 is a flowchart showing control procedure of the motor;
FIG. 7 shows another preferred embodiment of a motor control circuit in the control system according to the present invention;
FIGS. 8A and 8B show still another preferred embodiment of the motor control circuit and a combination of switches thereof according to the present invention;
FIG. 9 shows a further preferred embodiment of control system according to the present invention;
FIG. 10 shows a functional block diagram of the control system shown in FIG. 9;
FIG. 11 is a graph showing the relationship between the accelerator depression amount θ and the adjusting resistances R_1 and R_2;

FIGS. 12 to 14 are flowcharts showing control procedure of the motor; and

FIG. 15 shows a still further preferred embodiment of the motor control circuit according to the present invention;

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will now be described in detail with reference to the accompanying drawings.

Throughout the drawings, like reference numerals and letters are used to designate like or equivalent elements for the sake of simplicity of explanation.

First in FIG. 1, an electric automobile 1 comprises an engine 2 having a crankshaft pulley 2a to which a pulley 4a of a generator 4 is connected through a belt 3. A battery 5 is charged by the generator 4. The generator 4 also acts as a starter when the engine 2 starts. A drive gear 1b mounted on an axle shaft 1a is connected to a drive gear 6d of a motor 6 through an idler gear 7.

The motor 6 is a d.c. motor. The output of the engine 2 is converted into electrical energy. The battery 5 is then charged with the electrical energy. The motor 6 is thus driven by means of the charged electrical energy. Namely, the electric automobile 1 is a serial hybrid vehicle.

The engine 2 is a gasoline engine. As is shown in FIG. 2, a carburetor 8 is provided in an intake pipe 7. An air cleaner 9 is attached to the intake pipe 7 upstream the carburetor 8. Furthermore, a rotary actuater 10 composed of such as a stepping motor or a rotary solenoid is attached to a throttle valve 7a installed in the intake pipe 7.

There are provided protrusions on the outer periphery of the pulley 4a of the generator 4. A generator-rotating speed detection sensor 11 which is composed of such as an electromagnetic pickup detecting the protrusions is provided to face the protrusions.

A controller 20 consisting of a microcomputer comprises a CPU (central processing unit) 21, a ROM (read only memory) 22, a RAM (random access memory) 23 and an I/O (input/output) interface 24 connected to each other through a bus line [illegible] constant-voltage power supply 26 connected to the battery 5 through a relay contact of a control relay RY supplies electrical power to those components [illegible]

The control relay RY is also connected to the battery 5 through a key switch 27 and an ignition circuit 2b of the engine 2. Furthermore, a generator control circuit 4b and a motor control circuit 6e are connected to the battery 5 to be supplied with the electrical power.

Variable sensors including the generator-rotating speed sensor 11 and an accelerator depression amount sensor 12 are connected to an input port of the I/O interface 24. Also, a positive terminal of the battery 5 is connected to the input port to supply a terminal voltage thereto.

On the other hand, the rotary actuater 10, the ignition circuit 2b, the generator control circuit 4b and the motor control circuit 6e are connected to an output port of the I/O interface 24 through a drive circuit 28.

In the motor 6 as shown in FIG. 3, a series circuit of a shunt coil 6b and a normally-open contact of a relay switch SW1 is connected to the battery 5 in parallel to an armature coil 6a. Furthermore, a series circuit of a series coil 6c and an armature voltage adjusting resistor 13 is connected to the battery 5 in series to the armature coil 6a.

Accordingly, the motor 6 is switched to a series motor or a compound-wound motor by means of such as the relay switch SW1. Namely, the motor 6 is constituted as the series motor by disconnecting the shunt coil 6b from the battery 5 by means of the normally-open contact of the relay switch SW1 when the switch SW 1 is off. On the other hand, the motor 6 is constituted as the compound-wound motor by connecting the shunt coil 6b to the battery 5 due to closing of the normally-open contact when the switch SW1 is turned on. A resistance value of the armature voltage adjusting resistor 13 is adjusted by a resistance-control actuater 13a.

The ROM 22 is prestored with a control program and fixed data such as control data. On the other hand, the RAM 23 is stored with the data obtained after calculating output signals from each of the sensors and also a monitored-value of the terminal voltage of the battery 5.

Signals from each of the sensors are processed by the CPU 21 according to the control program prestored in the ROM 22. And then an engine-stop signal to the ignition circuit 2b, a control signal to the generator control circuit 4b, a drive signal to the rotary actuater 10 and a control signal to the motor control circuit 6e are calculated by the CPU 21.

The opening of the throttle valve 7a of the engine 2 is controlled by the rotary actuater 10 which is driven by the CPU 21. Furthermore, charging the battery 5 is controlled by the generator 4 whose rotation speed is adjusted to a specific value by the CPU 21. The motor 6 is also switched to the series or compound-wound motor-type by the CPU 21.

Next, the motor-type switching function of the controller 20 will be explained. Also in FIG. 3, the controller 20 comprises an accelerator depression amount calculation section 30, an accelerator de-

pression amount judging section 31, a motor-type selection section 32, an armature voltage adjusting resistance setting section 33, an armature voltage adjusting resistance map MR and a resistance-control actuater drive section 34.

An accelerator depression amount θ is calculated by the calculation section 30 on the basis of a signal from the sensor 12. The amount θ calculated by the calculation section 30 is judged by the judging section 31 for whether the amount θ is smaller than a preset value OSET or not.

The selection section 32 produces a signal when the amount a is judged to be smaller than the preset value θSET ($\theta < \theta$SET) in the judging section 31 and applies the signal to the motor control circuit 6e to turn on the relay switch SW1 so as to connect the shunt coil 6b to the battery 5. The motor 6 is thus switched from the series motor-type to the compound-wound motor-type. On the other hand, the relay switch SW1 is turned off to switch the motor 6 to the series motor-type if $\theta \geqq \theta$SET.

Namely, the shunt coil 6b of the motor 6 is intermittently connected to the battery 5 in response to a load such as the amount θ while the vehicle 1 is travelling. The motor 6 is thus switched to the series motor-type if the amount θ or the load is large and to the compound-wound motor-type if the amount θ or the load is small.

Therefore, as is understood from FIG. 4, the motor 6 can be driven under the best condition so that energy efficiency and travelling performance of the vehicle 1 can be improved.

In the setting section 33, an armature voltage adjusting resistance R of the motor 6 is retrieved from the map MR with the depression amount θ as a parameter.

Then, the actuater 13a is driven through the drive section 34 to set the value of the resistor 13 connected in series to the series coil 6c of the motor 6 to the resistance R thus retrieved from the map MR.

The resistance R which is inverse proportion to the amount θ is prestored in the map MR. Accordingly, the larger the amount θ, the smaller the resistance R becomes to boost a voltage applied to the armature coil 6a so as to produce the required torque and vehicle speed.

The operation of the preferred embodiment according to the present invention will be explained with reference to the flowchart shown in FIG. 6. This flowchart shows a program which is repeated per specific period of time or cycle while the electric vehicle 1 is travelling by the motor 6 which is started by turning on the key switch 27.

First in STEP 101, the depression amount θ from the sensor 12 is accepted. Then, the depression amount θ and a specific preset value θSET are compared with each other in STEP 102.

The program advances to STEP 103 from STEP 102 if $\theta \geqq \theta$SET. In STEP 103, the relay switch SW1 is turned off to select the series motor-type and the program advances to STEP 105.

On the other hand if $\theta < \theta$SET in STEP 102, the program advances to STEP 104 in which the relay switch SW1 is turned on to select the compound-wound motor-type and the program advances to STEP 105.

In STEP 105, the resistance R is retrieved from the map MR with the depression amount θ as a paramemter and the program advances to STEP 106.

In STEP 106, the actuater 13a is driven to adjust the resistor 13 of the motor 6 to the resistance R. Then, the program returns to STEP 101.

FIG. 7 shows another preferred embodiment according to the present invention. In the figure, a normally-closed contact of a relay SW2 as a switching means is connected in series to a shunt coil 6b which is connected in parallel to an armature coil 6a of a motor 6. And also an armature voltage adjusting resistor 40 is connected in series to a series coil 6c which is connected in series to the armature coil 6a.

A resistance-control slider 40a of the resistor 40 is, as depicted by a broken line, communicated to an accelerator 41 through a wire 43 and a link 42. The relay switch SW2 is interlocked by the accelerator 41 to be intermittently disconnected from a battery 5 through a limit switch SW3 operated according to a specific depression amount θAC.

The limit switch SW3 is usually opened when the depression amount of the accelerator 41 is small. Thus, the relay switch SW2 is on and the motor 6 is a compund-wound-type.

On the other hand, the limit switch SW3 is closed when the depression amount of the accelerator 41 becomes larger than θAC. Then, an electric power is supplied to the relay switch SW2 to open its contact so as to turn off the relay switch SW2. The shunt coil 6b is thus disconnected from the battery 5 and the motor 6 is switched to a series motor-type from the compound-wound-type. The slider 40a of the resistor 40 slides due to the wire being pulled in response to the depression amount or the load through the link 42. Therefore, the resistance 40 decreases to produce the required torque and vehicle speed in accordance with the increase of the load.

Next in FIG. 8A, a shunt coil 6b is connected in parallel to an armature coil 6a of a motor 6, and a series coil 6c is connected in series to the armature coil 6a. A switch SW4 is connected in series to the shunt coil 6b. A switch SW5 is connected in series to the series coil 6c. Furthermore,

a switch SW6 is connected in parallel to a series circuit of the series coil 6c and the switch SW5.

Namely as is shown in FIG. 8B, the motor-type selection section 32 controls a switching means such as the switches SW4, SW5 and SW6 so that the motor 6 operates as a compound-wound motor, a shunt motor or a series motor according to the travelling state. The switch SW5 may be eliminated since it is to surely disconnect the series coil 6c from the battery 5.

As is shown in FIG. 9, the engine 2 in further preferred embodiment of the present invention has a vehicle speed sensor 30 and a current sensor 14 connected to the battery 5 at its positive terminal are connected to the input port of the I/O interface 24. An alarm LED is connected to the drive circuit 28. Other configuration in FIG. 9 is the same as that in FIG. 2.

A motor control circuit 60e will be explained with reference to FIG. 10. In the figure, a field current/voltage adjusting resistor 16 is connected in series to a shunt coil 6b. Furthermore, a relay contact (corresponding to the switch SW4 in FIG. 8A) of a relay switch SW10 is connected in series to the resistor 16.

An armature voltage adjusting resistor 13 is connected in series to a series coil 6c. A relay contact (corresponding to the switch SW5 in FIG. 8A) of a relay switch SW20 is connected in series to the resistor 13. A relay contact (corresponding to the switch SW6 in FIG. 8A) of a relay switch SW30 is connected in parallel to the series circuit of the series coil 6c, the resistor 13 and the relay contact of the relay switch SW20.

The values of the resistors 13 and 16 are adjusted by resistance-control actuaters 13a and 16a, respectively.

The ROM 22 is presotroed with a control program and fixed data such as control data. On the other hand, the RAM 23 is stored with data obtained after calculating output signals from each of the sensors and also a monitored-value of the terminal voltage of the battery 5.

Signals from each of the sensors are processed by the CPU 21 according to the control program prestored in the ROM 22. Then, an engine-stop signal to the ignition circuit 2b, a control signal to the generator control circuit 4b, a drive signal to the rotary actuator 10 and a control signal to the control circuit 60e are calculated by the CPU 21.

[illegible] engine 2 is controlled by the rotary actuater 10 which is driven by the CPU 21. Furthermore, charging to the battery 5 is controlled by the generator 4 whose rotation speed is adjusted to a specific value by the CPU 21. The motor 6 is also switched between the series, the shunt or the compound-wound motor-type by the CPU 21, according to the traveling state of the vehicle 1.

As is also shown in FIG. 10, the controller 200 comprises a consumed-power calculation section 300, a consumed-power judging section 310, an alarm drive section 320, an accelerator depression amount calculation section 330, an accelerator depression amount judging section 340, a consumed current judging section 350, a vehicle speed judging section 360, a battery terminal voltage judging section 370, a motor-type selection section 380, an armature voltage adjuting resistnace setting section 390, an armature voltage adjusting resistnace map MR2, an armature voltage adjusting resistance-control actuater drive section 400, a field current adjusting resistance setting section 410, a field current adjusting resistance map MR1, a field current adjusting resistance-control actuater drive section 420.

A consumed power W is calculated by means of a terminal voltage V_B of the battery 5 and a consumed current A of the motor 6 detected by the sensor 14 ($W = V_B \times A$) in the calculation section 300.

The consumed power W thus calculated is judged as to whether it is smaller than a specific preset value WSET in the judging section 310.

The alarm LED 15 is then turned on by the alarm drive section 320 to warn a driver if it is judged in the judging section 310 that the calculated consumed power W exceeds the preset value WSET.

On the othe hand, a depression amount θ is calculated in the calculation section 330 based on a signal from the sensor 12.

The depression amount θ thus calculated is judged as to whether it is smaller than a specific preset value OSET or not in the judging section 340 if the calculated consumed power W is judged smaller than the preset value WSET in the judging section 310.

The consumed current A detected by the sensor 14 is judged as to whether it is larger than a specific preset value ASET or not in the judging section 350 if the calculated depression amount θ is judged larger than the preset value OSET in the judging section 340.

Furhtermore, a vehicle speed S detected by the sensor 30 is judged as to whether it is smaller than a specific preset value SSET in the judging section 360 if the detected consumed current A is judged to be larger than the preset value ASET in the judging section 350.

The terminal voltage V_B of the battery 5 is judged as to whether it is smaller than a specific preset value VSET in the judging section 370 if the calculated consumed power W is judged to be larger than the preset value WSET in the judging

section 310.

All the judging results of the judging sections 310, 340, 350, 360 and 370 are received by the selection section 380 to select the type of the motor 6 among the series motor-type, the chunt motor-type and the compound-wound motor-type.

The relay switches SW10 and SW30 are turned off and the relay switch SW20 is turned on in the motor control circuit 30e if the series motor-type is selected.

The relay switches SW10 and SW30 are turned on and the relay switch SW20 is turned off if the shunt motor-type is selected.

Furthermore, the relay switches SW10 and SW20 are turned on and the relay switch SW30 is turned off if the compound-wound motor-type is selected.

Namely, the motor 6 is set up as the compound-wound motor without any condition to reduce the power consumption if the present consumed power W is larger than the preset value WSET. The motor 6 is also set up as the compound-wound motor to restrict power reduction of the battery 5 if the consumed power W and the depression amount θ are smaller than preset values WSET and θSET, respectively.

On the other hand, the motor 6 is set up as the series motor under the travelling state that the vehicle speed S is lower than the preset value SSET and a larger torque is required if the consumed power W is smaller than the preset value WSET and the depression amount θ is larger than the preset value θSET. Furthermore, the motor 6 is set up as the shunt motor under the travelling state that the vehicle speed S is higher than the preset value SSET and a large torque is not required but a stable vehicle speed is required.

Therefore, the motor 6 can be driven under the best condition of the characteristics shown in FIG. 4 according to the travelling state to improve energy efficiency and the travelling performance greatly.

In the setting section 390, an armature voltage adjusting resistance R2 of the motor 6 is retrieved from the map MR2 with the depression amount θ calculated by the calculation section 330 as a parameter a when the motor 6 is set up as the series motor or the compound-wound motor in the selection section 380.

The actuator 13a is then driven through the drive section 400 to adjust the resistor 13 connected in series to the series coil 6c of the motor 6 to the resistance R2.

In the setting section 410, a field current adjusting resistance R1 is retrieved from the map MR1 with the depression amount θ calculated by the calculation section 330 as a parameter θ when the motor 6 is set up as the shunt motor or the compound-wound motor in the selection section 380.

The actuator 16a is then driven through the drive section 420 to adjust the resistor 16 connected in series to the shunt coil 6b of the motor 6 to the resistance R1.

As is shown in FIG. 11, the resistance R1 and R2 which are inverse proportion to the depression amount θ are prestored in the maps MR1 and MR2, respectively. The larger the depression amount θ, the smaller the resistance R1 and R2 to boost voltages applied to the sarmature coil 6a and the series coil 6c in the case of the series motor-type. The current applied to the shunt coil 6b are made larger and the current applied to the armature coil 6a is made smaller with the increase of the depression amount θ in the case of the shunt motor. A combination of the above two cases are brought into the compound-wound motor-type when selected.

The operation of the further preferred embodiment according to the present invention will be explained with reference to the flowcharts shown in FIGS. 12 to 14. These flowcharts show a program which is repeated per specific period of time or cycle while the electic vehicle 1 is travelling by the motor 6 which is started by turning on the key switch 27.

First in STEP 201 shown in FIG. 12, a terminal voltage V_B of the battery 5 and a consumed current A of the motor 6 detected by the sensor 14 are accepted.

In STEP 202, a consumed power W associated with the operation of the motor 6 is calculated by means of the terminal voltage VB and the consumed current A thus accepted ($W = V_B \times A$). Then, the program advances to STEP 203.

The calculated consumed power W is compared with the preset value WSET in STEP 203. The program advances to STEP 219 shown in FIG. 14 if W > WSET. On the other hand, the program advances to STEP 204 in which a drive signal is stopped to turn off the alarm LED 15. Then, the program advances to STEP 205.

The accelerator depression amount a is accepted in STEP 205. The depression amount θ is compared with a preset value OSET in STEP 206 shown in FIG. 13. The program advances to STEP 207 if $\theta \leqq \theta$SET, in which the relay switches SW10 and SW20 are turned on and the relay switch SW30 is turned off to set up the motor 6 as the compound-wound motor-type. Then, the program advances to STEP 208.

In STEP 208, the resistances R1 and R2 are respectively retrieved from the maps MR1 and MR2 with the depression amount θ as a parameter. The program then advances to STEP 209.

The actuators 16a and 13a are driven to set

each of values of the resistors 16 and 13 to the resistances R1 and R2 determined in STEP 208. Then, the program returns to STEP 201.

On the other hand, if θ > θSET in STEP 206, the program advances to STEP 210. The consumed current A accepted in STEP 201 and a preset value ASET are compared with each other in STEP 210. Then, the program advances to STEP 213 if A < ASET, while to STEP 211 if A ≧ ASET. A vehicle speed S is accepted from the sensor [illegible] in STEP 211. Then, the vehicle speed S and a preset value SSET are compared with each other in STEP 212. The program advances on [illegible].

In STEP 213, the relay switches SW10 and SW30 are turned off and the relay switch SW20 in turned on in the motor control circuit 60e to select the series motor-type.

Next in STEP 214, the resistance R2 is retrieved from the map MR2 with the depression amount θ as a parameter accepted in STEP 205. Then, the program advances to STEP 215.

The actuator 13a is driven to set the rsistor 13 to the resistance R2 determined in STEP 114. Then, the program returns to STEP 201.

Furthemore if S > SSET in STEP 212, the program advances to STEP 216. In STEP 216, the relay switches SW10 and SW30 are turned on and the relay switch SW20 is turned off in the motor control circuit 60e to select the shunt motor-type. Then, the program advances to STEP 217.

In STEP 217, the resistance R_1 is retrieved from the map MRI with the depression amount θ as a paramemter accepted in STEP 205. The program advances to STEP 218.

The actuater 16a is driven to set the value of the resistor 16 to the resistance R_1 determined in STEP 217. Then, the program returns to STEP 201.

Still furthermore, the program advances to STEP 219 from STEP 203 if the calculated consumed power W is larger than the preset value WSET.

In STEP 219, the alarm LED 15 is turned on and then in STEP 220 the relay swithes SW10 and 20 are turned on and the relay swith SW30 is turned off to select the compound-wound motor-type. Then, the program advances to STEP 221.

A depression amount θ from the sensor 12 is accepted in STEP 221 and then in STEP 222, the resistance R_1 and R_2 are respectively retrieved from the maps MR1 and MR2 [illegible] amount 5 as a paramemter accepted in STEP 221. The program advances to STEP 223.

The actuators 16a and 13a are driven to set each of values of the resistors 16 and 13 to the resistances R_1 and R_2 determined in STEP 222. The program then advances to STEP 224.

In STEP 224, the terminal voltage V_B is again accepted and then in STEP 225, the terminal voltage V_B and the preset reference voltage VSET are compared [illegible]. The program returns to STEP 220 to set the motor to the compound-wound motor-type if V_B ≦ VSET and the program returns to STEP 201 to determine the motor-type again if V_B > VSET.

Next, FIG 15 shows a still further proferred embodiment according to the present invention. In the figure, a field current adjusting resistor 50 connected to a shunt coil 6b of a motor 6 and an armature voltage adjusting resistor 51 connected to [illegible] accelerator 52 through wires 54a and 54b and a link 53.

Connection of an armature coil 6a to the shunt coil 6b and also the series coil 6c are switched by a switching means composed of an interlocked switch SW40 which is operated by the motor-type selection section 380 according to travelling condition.

FIG. 15 now represents the compound-wound motor-type. The motor 6 is then switched to the shunt motor-type when three contactors of the switch SW40 are switched one stage downward, respectively. The motor 6 is switched to the series motor-type when each contactor of the switch SW40 is switched one more stage downward.

The wires 54a and 54b are pulled through the link 53 when the accelerator 52 is depressed to make values of the resistance 50 and 51 less so as to obtain the required torque and a vehicle speed.

As is understood from the foregoing, the present invention provides a switching means for switching connection between an armature coil and a series coil and a shunt coil of a vehicle motor according to travelling condition. One motor is thus switched to a compound-wound motor-type, a series motor-type and a shunt motor-type to obtain best motor characteristics matching with the traveling condition. Therefore, such as vehicle performance and cost performance are greatly improved.

While the presently preferred embodiments of the

Claims

1. A switching apparatus [illegible] an armature coil, [illegible] coil and connecting the [illegible] and [illegible]

first switching means for connecting the shunt coil to the series circuit in parallel to [illegible] coil to set up the motor as a [illegible] when the shunt coil is connected to the series circuit, while set up as a series motor as soon as disconnected therefrom.

2. The apparatus according to claim 1, further comprising:
detection means for detecting a depression amount of an accelerator of the vehicle;
judging means having a depression amount-preset value for judging whether the amount of depression is larger than the preset value or not; and
selection means responsive to the judging means for controlling the first switching means to set up the motor as a series motor when the depression amount is larger than the preset value and as a compound-wound motor when the former is smaller than the latter.

3. The apparatus according to claim 1, further comprising:
detection means for detecting a depressionn amount of an accelerator of the vehicle;
variable resistor means connected to the series circuit for adjusting an armature voltage to be applied to the armature coil;
setting means for setting an armature voltage adjusting resistance in accordance with the depression amount; and
adjusting means responsive to the setting means for adjusting the value of the variable resistor means to the armature voltage adjusting resistance, wherein,
the depression amount becomes larger the amature voltage becomes larger.

4. The apparatus according to claim 1, further comprising:
an accelerator mounted on the vehicle;
a first variable resistor connected between the series coil and the battery and provided with a slider for sliding to vary the resistance thereof; and
connecting means for connecting the accelerator and the slider of the variable resistor to move the slider in responce to a depression amount of the accelerator.

5. The apparatus according to claim 2, wherein
the first switching means is a first relay with a first coil controlled by the selection means and a first terminals disposed between the shunt coil and the series circuit.

6. The apparatus according to claim 2, wherein
the first switching means comprises a first switch disposed between the series coil and the battery, a second switch disposed between the shunt coil and a point between the first switch and the battery and a third switch in a line parallel to the series coil and the first coil, the first, second and third switch controlled by the selection means to set up the motor as one of a series motor, a compound-wound motor and a shunt motor.

7. The apparatus according to claim 1, further comprising:
second switching means for disconnecting the series coil from the series circuit to set up the motor as a shunt motor when the shunt coil is connected to the series circuit and the series circuit is disconncted therefrom.

8. The apparatus according to claim 7, further comprising:
calculation means for calculating a consumed power of the motor;
judging means having a consumed power-preset value for judging whether the consumed power is larger than the preset value or not; and
selection means responsive to the judging means for controlling the first and second switching means to set up the motor as a compund-wound motor when the consumed power is larger than the preset value.

9. The apparatus according to claim 8, wherein
the second switching means is a second relay with a second coil controlled by the selection means and a second terminals disposed between the series coil and a connecting point of the first relay and the battery.

10. The apparatus according to claim 7, further comprising:
detection means for detecting a depression amount of an accelerator of the vehicle;
judging means having a depression amount-preset value for judging whether the amount of depression is larger than the preset value or not; and
selection means responsive to the judging means for controlling the first and second switching means to set up the motor as a compound-wound motor when the depression amount is smaller than the preset value.

11. The apparatus according to claim 10, wherein
the second switching means is a second relay with a second coil controlled by the selection means and a second terminals disposed between the series coil and a connecting point of the first relay and the battery.

12. The apparatus according to claim 7, further comprising:
detection means for detecting a consumed current of the motor;
judging means having a consumed current-preset value for judging wether the consumed current is larger than the preset value or not; and
selection means responsive to the judging means for controlling the first and second switching means to set up the motor as a series motor when the consumed current is smaller than the preset value.

13. The apparatus according to claim 12, wherein
the second switching means is a second relay with a second coil controlled by the selection means and a second terminals disposed between the series coil and a connecting point of the first relay and the battery.

14. The apparatus according to claim 7, further comprising:

detection means for detecting a vehicle speed;
judging means having a vehicle speed-preset value for judging whether the vehicle speed is larger than the preset value or not; and
selection means responsive to the judging means for controlling the first and second switching means to set up the motor as a series motor when the vehicle speed is smaller than the preset value and as a shunt motor when the former is larger than the latter.

15. The apparatus according to claim 14, wherein the second switching means is a second relay with a second coil controlled by the selection means and a second terminals disposed betw[illegible]ries coil and a connecting point of the first relay and the battery.

16. The apparatus according to claim 7, further comprising:
detection means for detecting a depression amount of an accelerator of the vehicle;
variable resistor means connected to the shunt coil for adjusting field current;
setting means for setting the field current adjusting resistance in accordance with the depression amount when the accelerator is depressed, by means of the memory means; and
adjusting means responsive to the setting means for adjusting the value of the variable resistor means to the field current adjusting resistance, wherein,
the depression amount becomes larger the field current become larger.

17. The apparatus according to claim 7, further comprising:
calculation means for calculating a consumed power of the motor;
judging means having a consumed power-preset value for judging whether the consumed power is larger than the preset value or not; and
warning means responsive to the judging means for warning of the state that the consumed power is larger than the preset value.

18. The apparatus according to claim 4, further comprising:
a second variable resistor connected between the shunt coil and the battery and provided with a second slider to be operated by the accelerator through the connecting means for varying the resistance thereof.

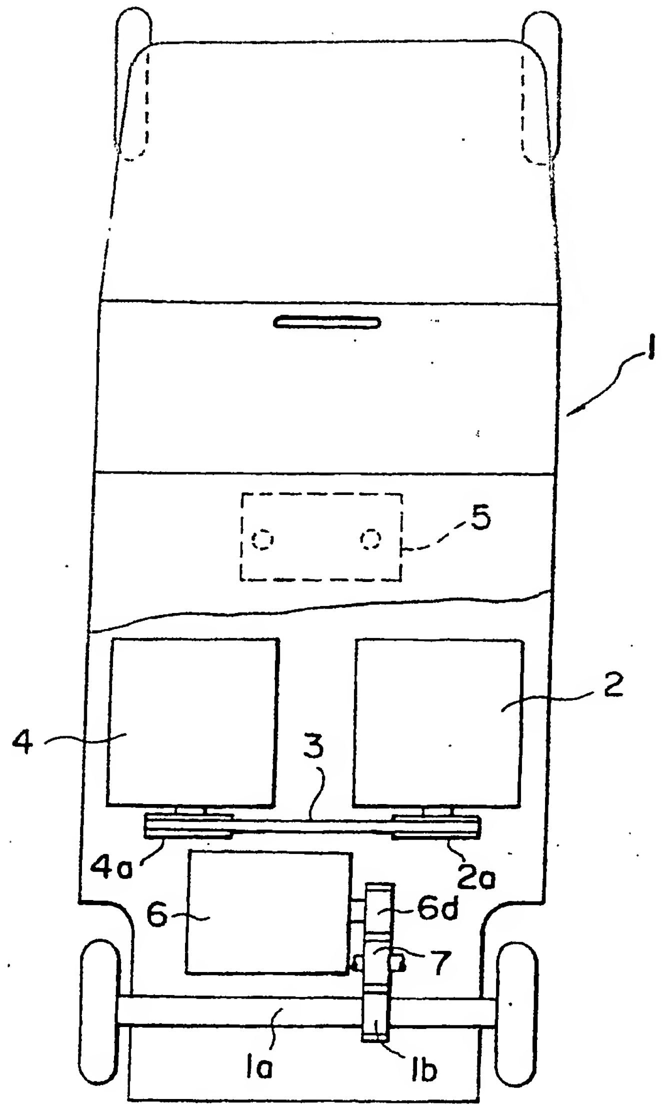


FIG. 1

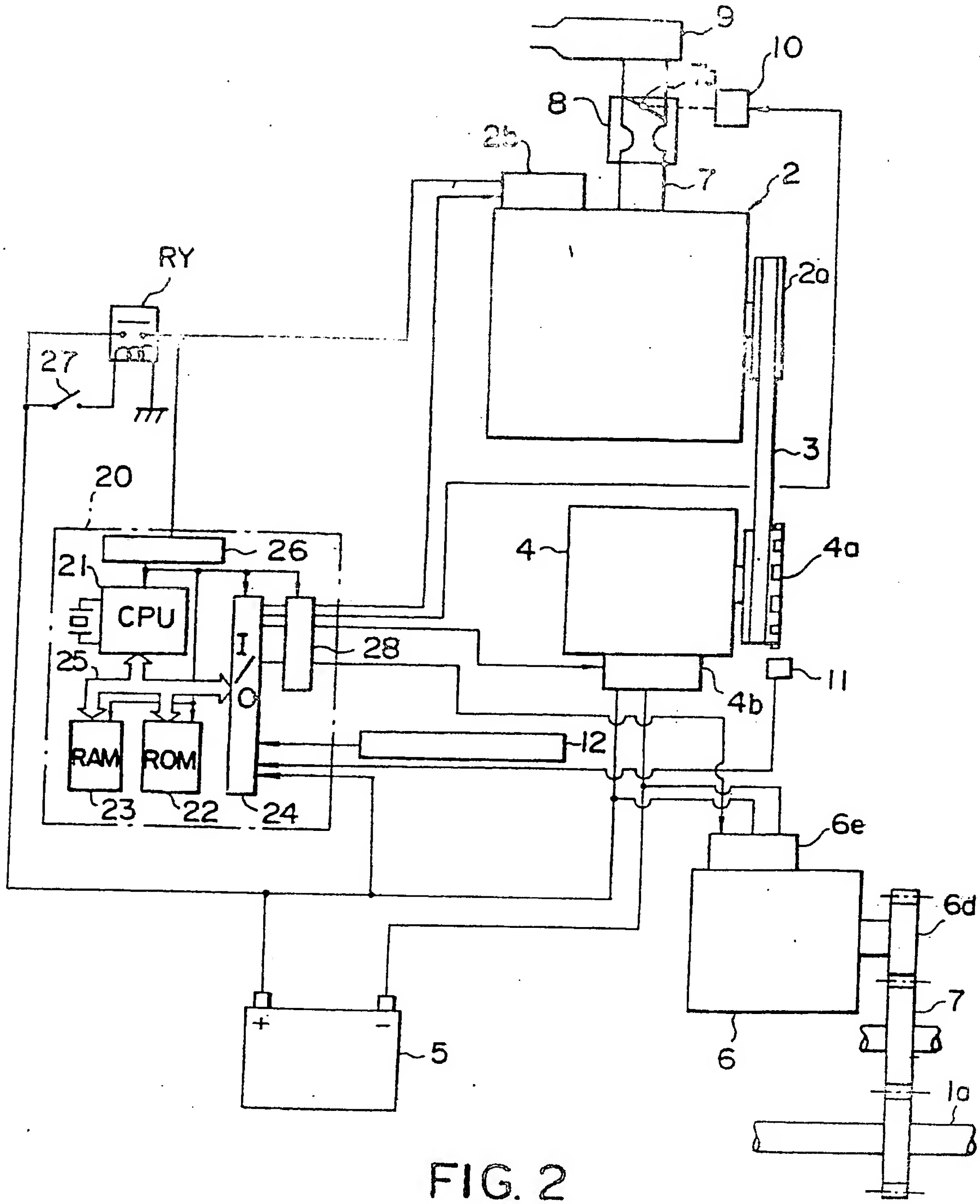

9
10
8
2b
7
2
RY
2a
27
3
20
26
4
4a
21
CPU
28
25
I/O
11
4b
RAM
ROM
12
23
22
24
6e
6d
7
5
6
1a

FIG. 2

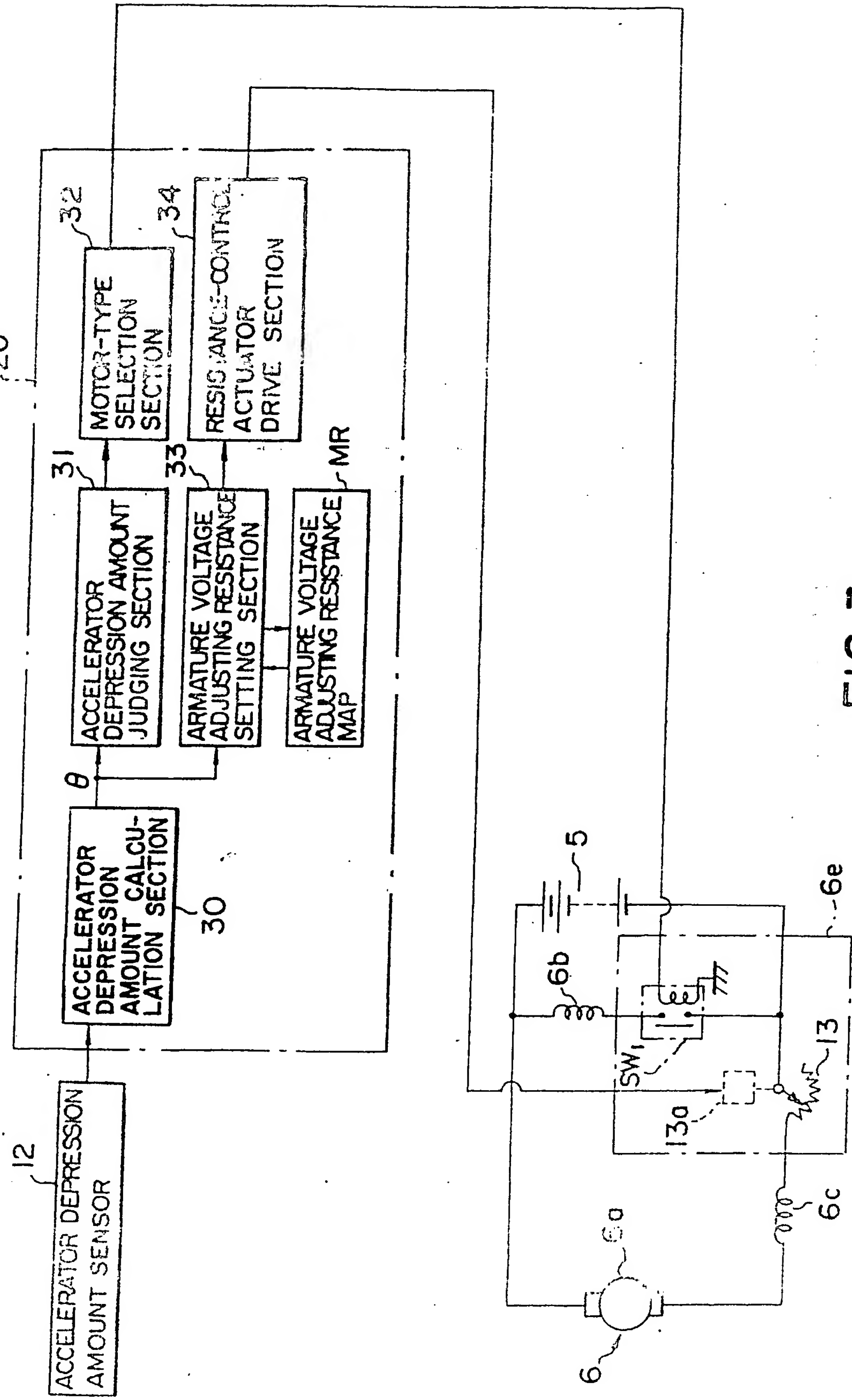

ACCELERATOR DEPRESSION AMOUNT SENSOR
12
20
ACCELERATOR DEPRESSION AMOUNT CALCU-LATION SECTION
30
θ
ACCELERATOR DEPRESSION AMOUNT JUDGING SECTION
31
MOTOR-TYPE SELECTION SECTION
32
ARMATURE VOLTAGE ADJUSTING RESISTANCE SETTING SECTION
33
RESISTANCE-CONTROL ACTUATOR DRIVE SECTION
34
ARMATURE VOLTAGE ADJUSTING RESISTANCE MAP
MR
5
6e
6b
SW1
13
13a
6c
6a
6

FIG. 3

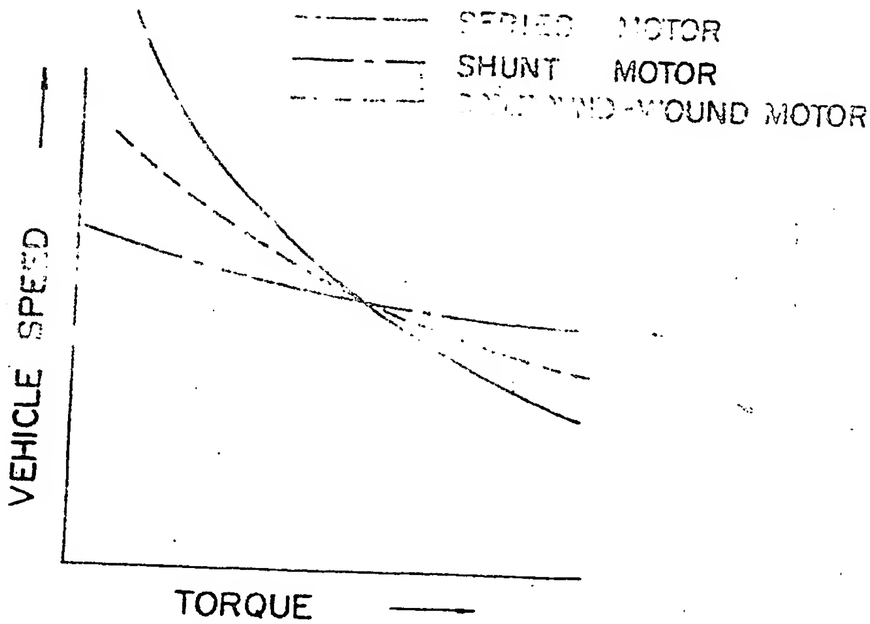

SHUNT MOTOR
VEHICLE SPEED
TORQUE

FIG. 4

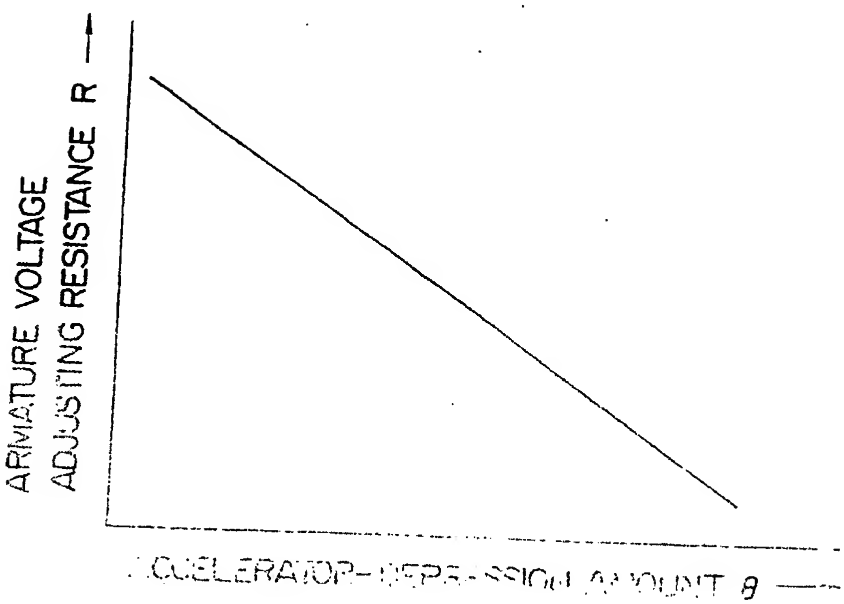

ARMATURE VOLTAGE
ADJUSTING RESISTANCE R

FIG. 5

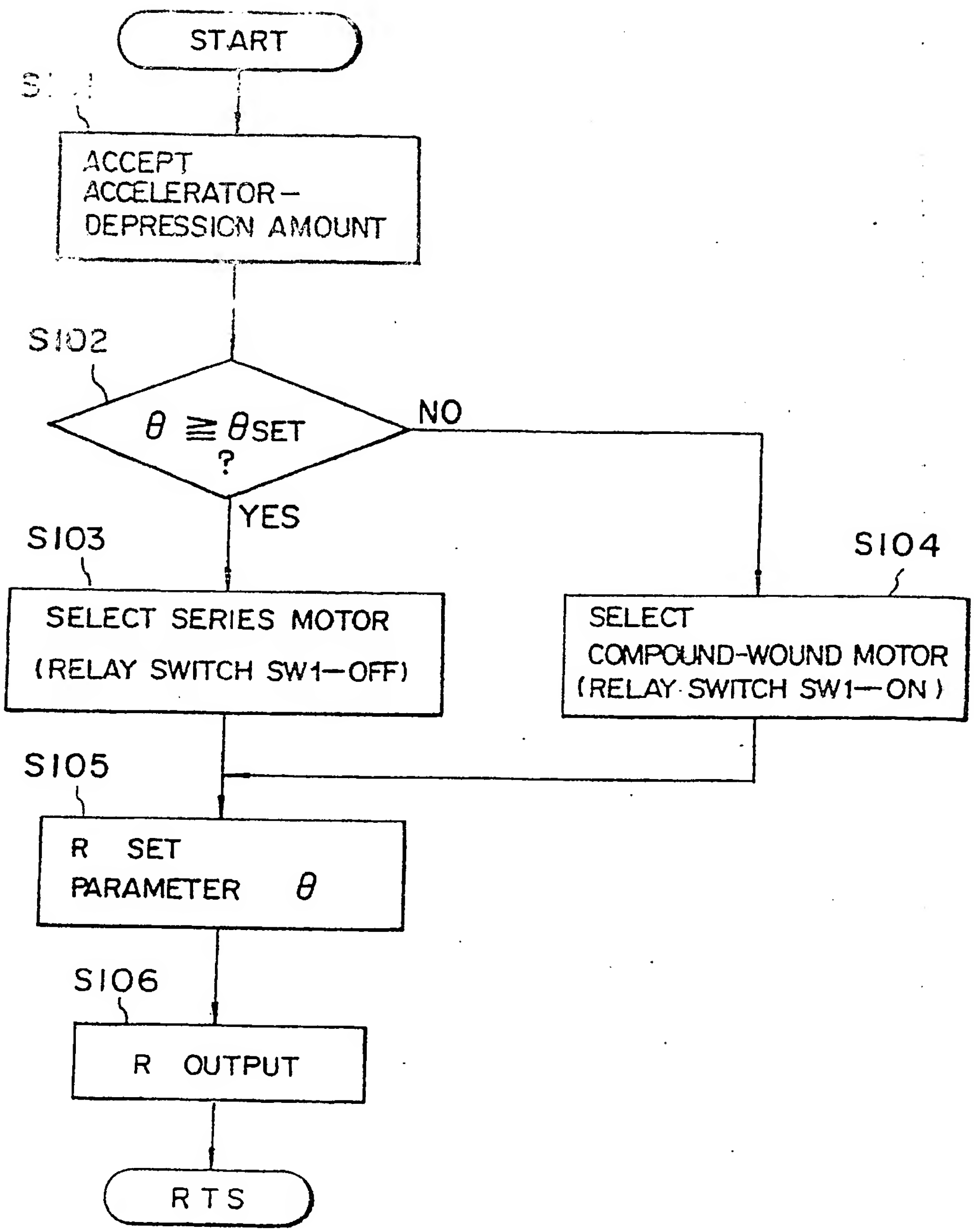

START
S101
ACCEPT ACCELERATOR-DEPRESSION AMOUNT
S102
θ ≧ θSET ?
NO
YES
S103
SELECT SERIES MOTOR (RELAY SWITCH SW1—OFF)
S104
SELECT COMPOUND-WOUND MOTOR (RELAY SWITCH SW1—ON)
S105
R SET PARAMETER θ
S106
R OUTPUT
RTS

FIG. 6

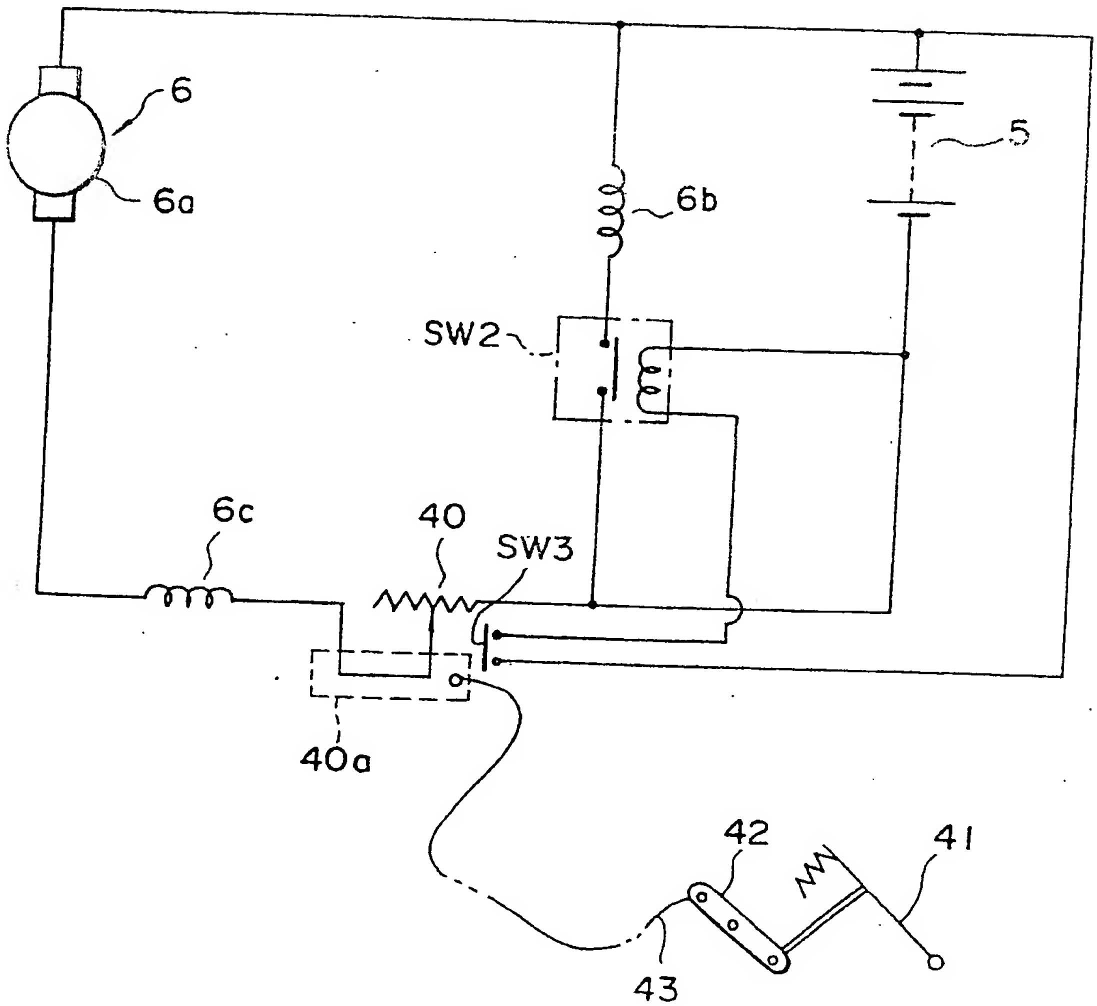


FIG. 7

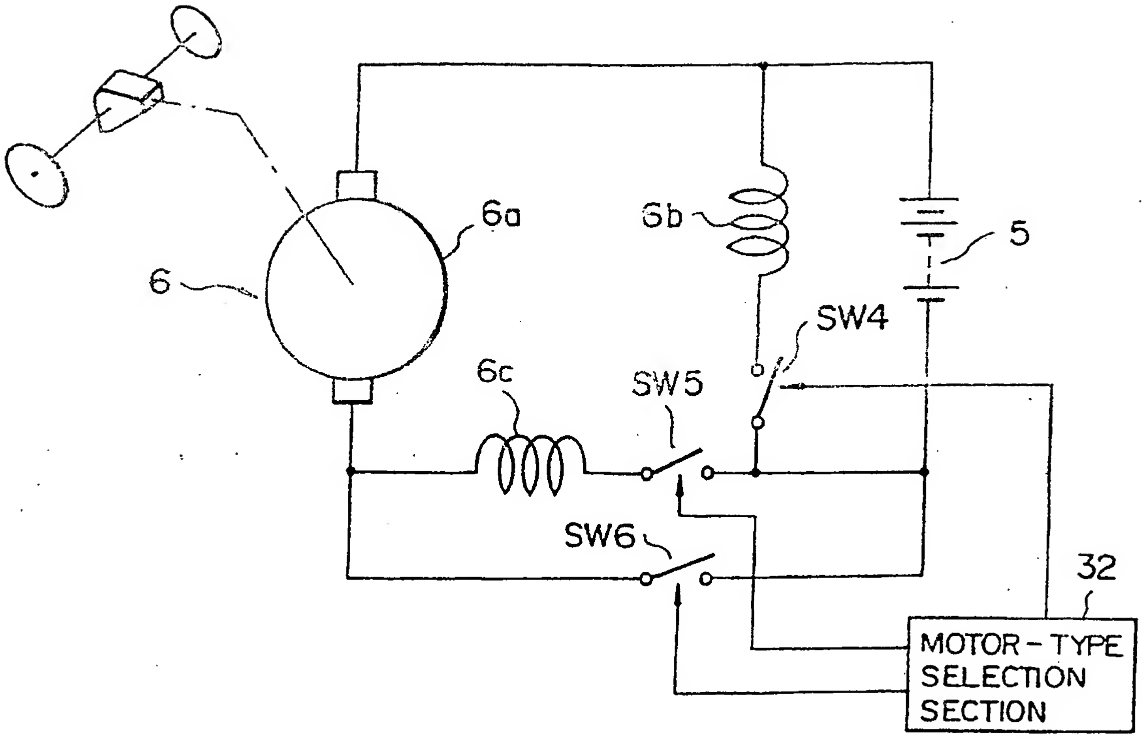


FIG. 8A

	SERIES MOTOR	SHUNT MOTOR	COMPOUND-WOUND MOTOR
SW4	OFF	ON	ON
SW5	ON	OFF	ON
SW6	OFF	ON	OFF

FIG. 8B

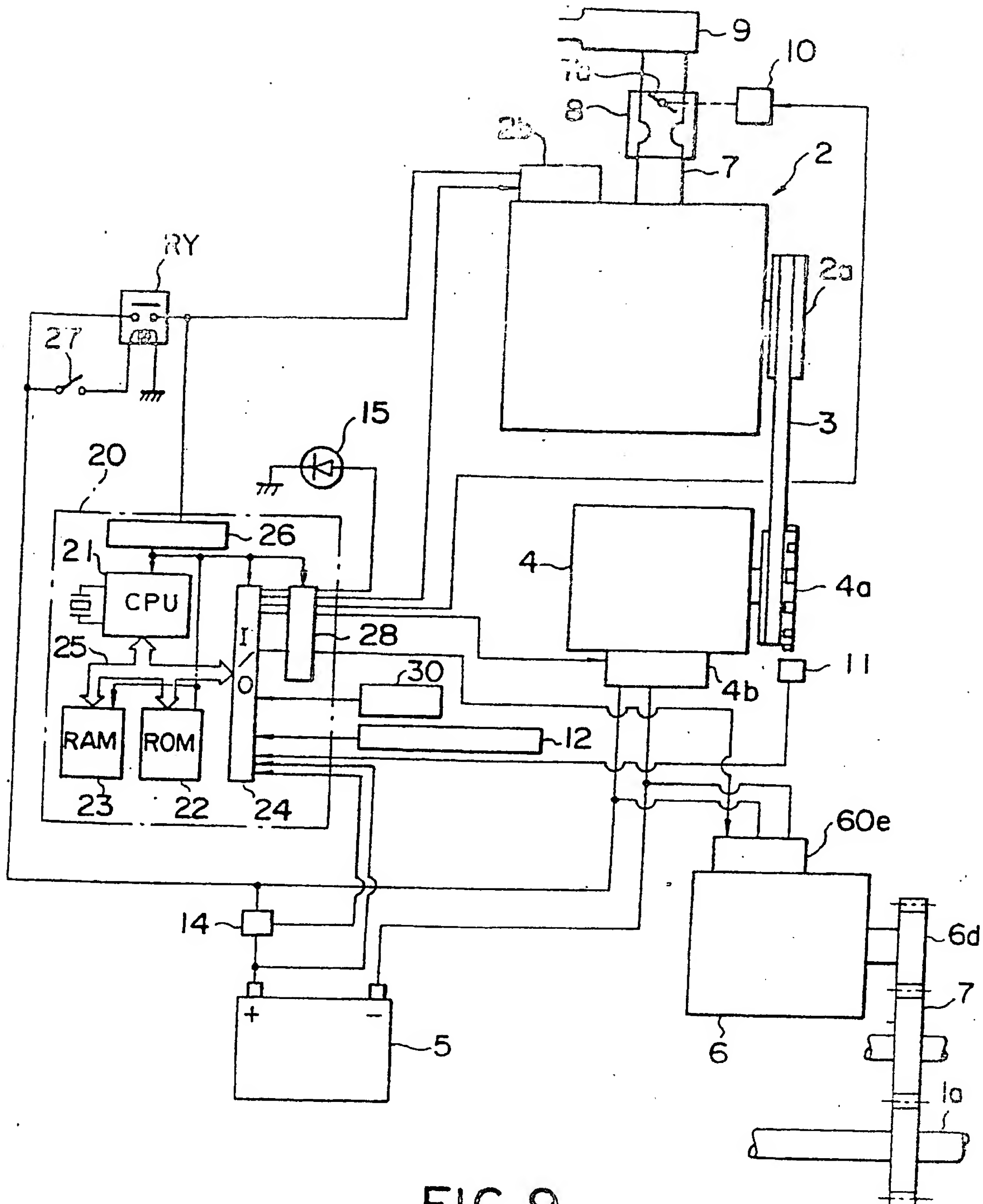

9
10
7a
8
2b
7
2
2a
RY
27
15
3
20
26
21
CPU
4
4a
25
28
I/O
30
11
4b
RAM
ROM
12
23
22
24
60e
14
6d
7
5
6
1a

FIG. 9

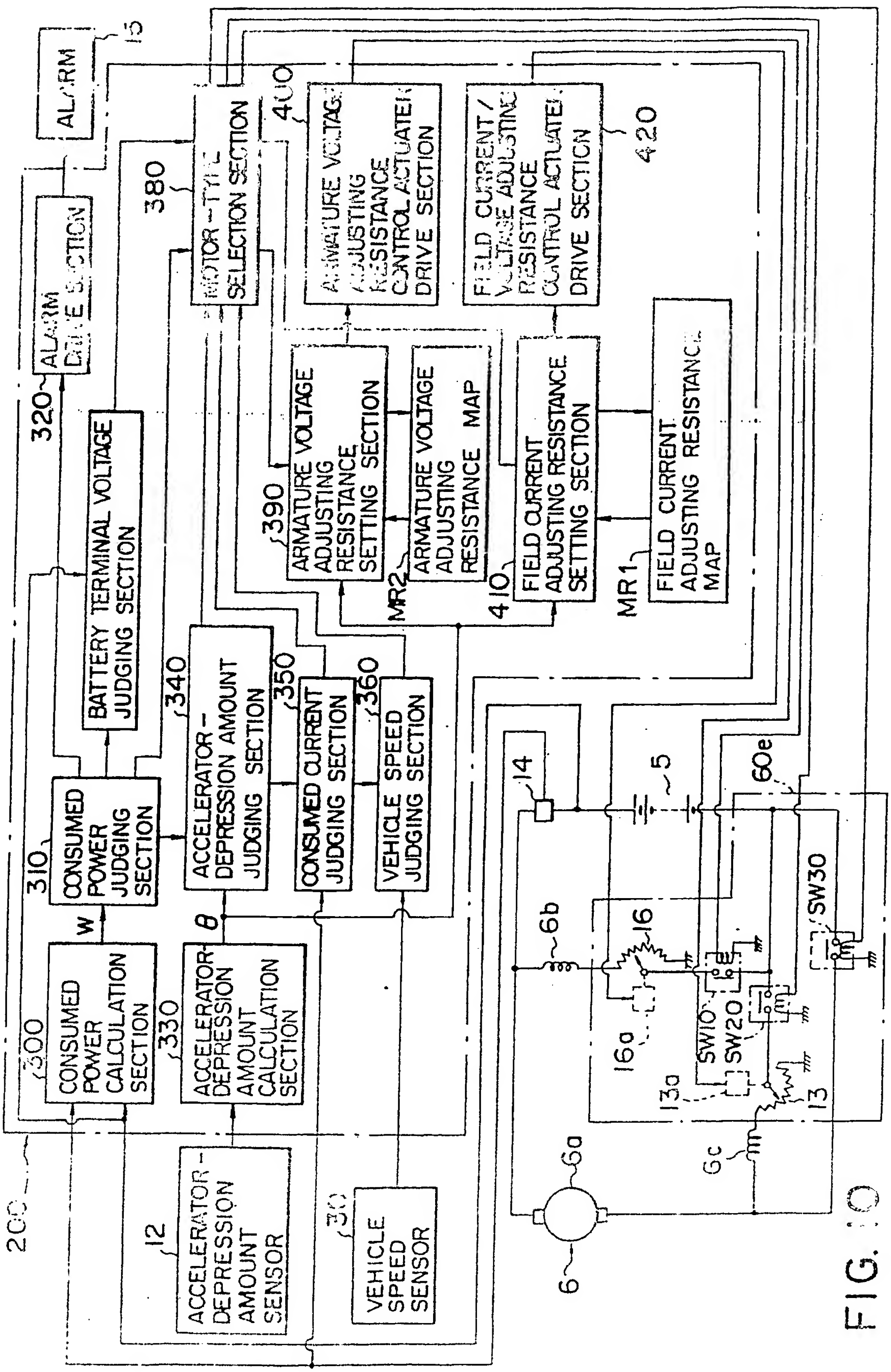

ALARM
15
ALARM DRIVE SECTION
320
MOTOR-TYPE SELECTION SECTION
380
ARMATURE VOLTAGE ADJUSTING RESISTANCE CONTROL ACTUATER DRIVE SECTION
400
FIELD CURRENT / VOLTAGE ADJUSTING RESISTANCE CONTROL ACTUATER DRIVE SECTION
420
BATTERY TERMINAL VOLTAGE JUDGING SECTION
ARMATURE VOLTAGE ADJUSTING RESISTANCE SETTING SECTION
390
ARMATURE VOLTAGE ADJUSTING RESISTANCE MAP
MR2
FIELD CURRENT ADJUSTING RESISTANCE SETTING SECTION
410
FIELD CURRENT ADJUSTING RESISTANCE MAP
MR1
CONSUMED POWER JUDGING SECTION
310
ACCELERATOR-DEPRESSION AMOUNT JUDGING SECTION
340
CONSUMED CURRENT JUDGING SECTION
350
VEHICLE SPEED JUDGING SECTION
360
W
θ
CONSUMED POWER CALCULATION SECTION
300
ACCELERATOR-DEPRESSION AMOUNT CALCULATION SECTION
330
200
ACCELERATOR-DEPRESSION AMOUNT SENSOR
12
VEHICLE SPEED SENSOR
30
14
5
60e
6b
16
SW30
16a
SW10
SW20
13a
13
6c
6a
6

FIG. 10

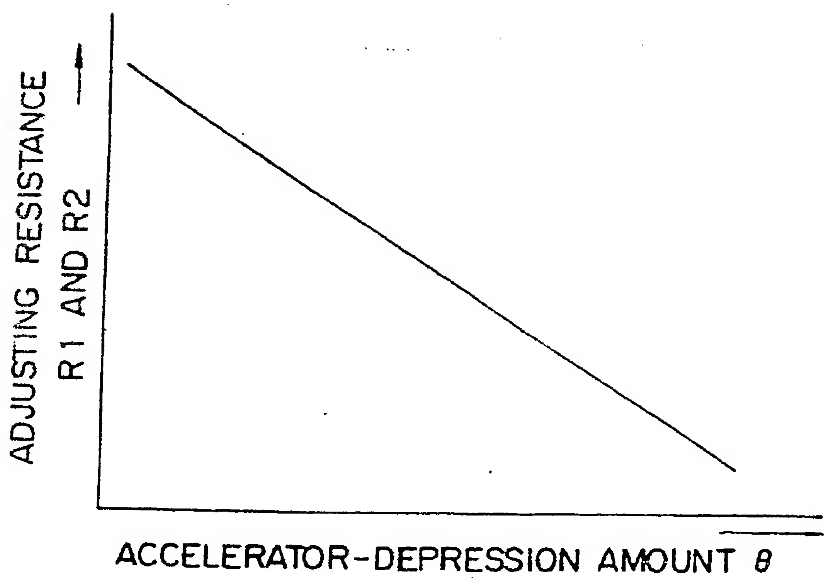

ADJUSTING RESISTANCE
R1 AND R2
ACCELERATOR-DEPRESSION AMOUNT θ

FIG. 11

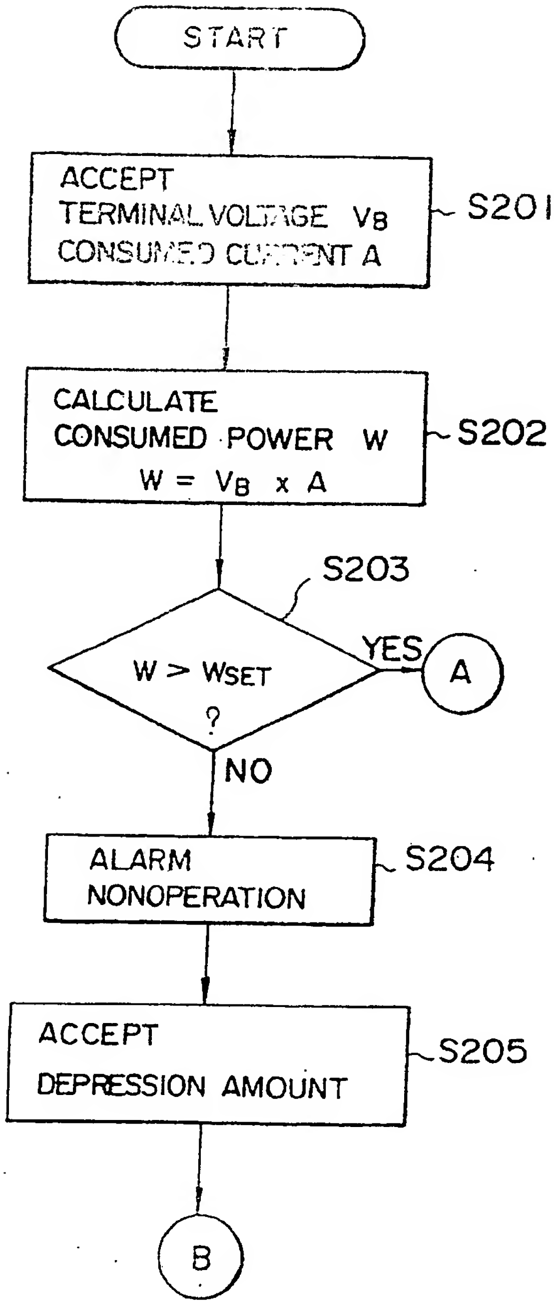
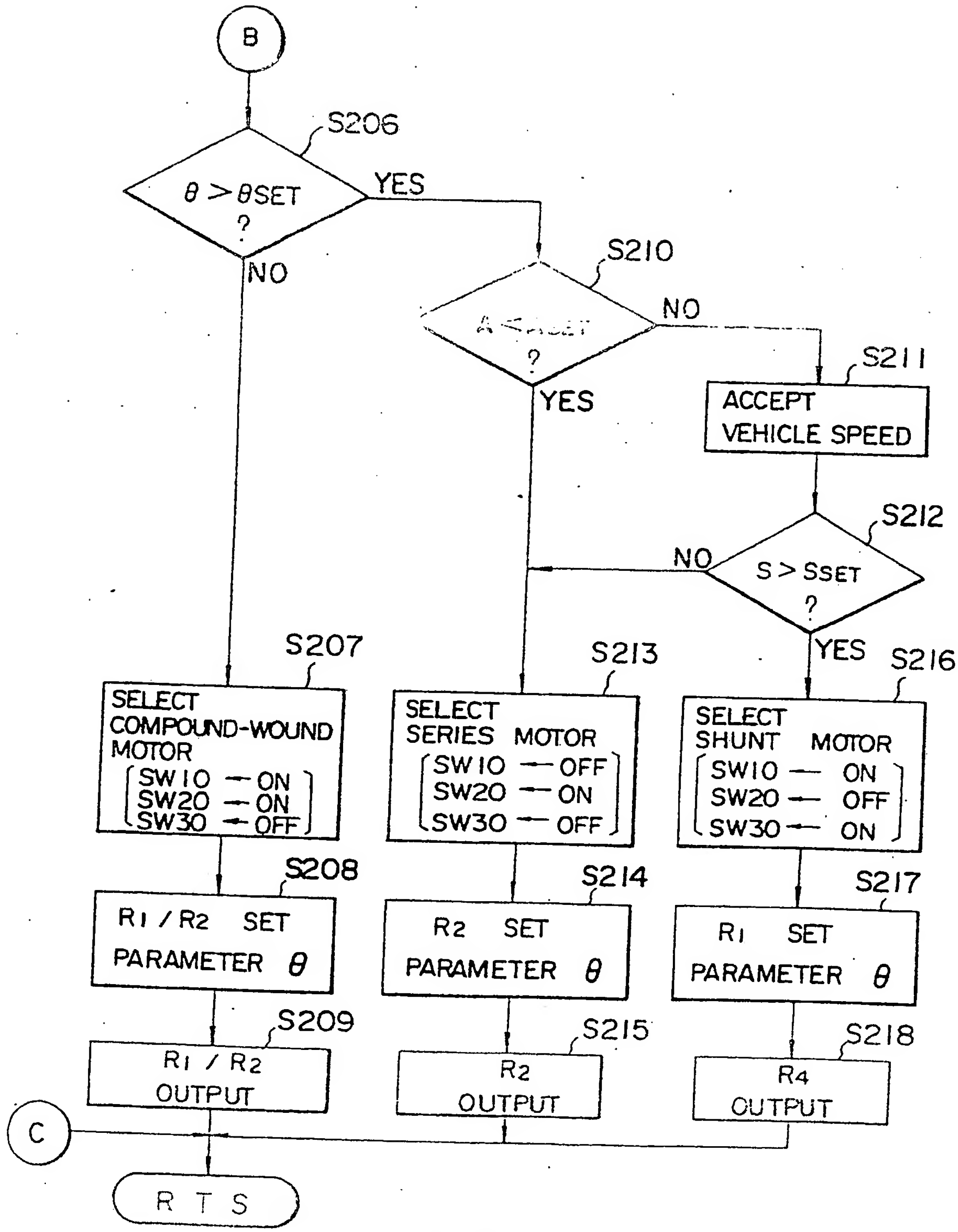

START
ACCEPT
TERMINAL VOLTAGE VB
CONSUMED CURRENT A
S201
CALCULATE
CONSUMED POWER W
W = VB x A
S202
S203
W > WSET
?
YES
A
NO
ALARM
NONOPERATION
S204
ACCEPT
DEPRESSION AMOUNT
S205
B

FIG. 12


B
S206
θ > θSET ?
YES
NO
S210
?
NO
YES
S211
ACCEPT VEHICLE SPEED
S212
S > SSET ?
NO
YES
S207
SELECT COMPOUND-WOUND MOTOR
SW10 — ON
SW20 — ON
SW30 — OFF
S213
SELECT SERIES MOTOR
SW10 — OFF
SW20 — ON
SW30 — OFF
S216
SELECT SHUNT MOTOR
SW10 — ON
SW20 — OFF
SW30 — ON
S208
R1 / R2 SET
PARAMETER θ
S214
R2 SET
PARAMETER θ
S217
R1 SET
PARAMETER θ
S209
R1 / R2
OUTPUT
S215
R2
OUTPUT
S218
R4
OUTPUT
C
R T S

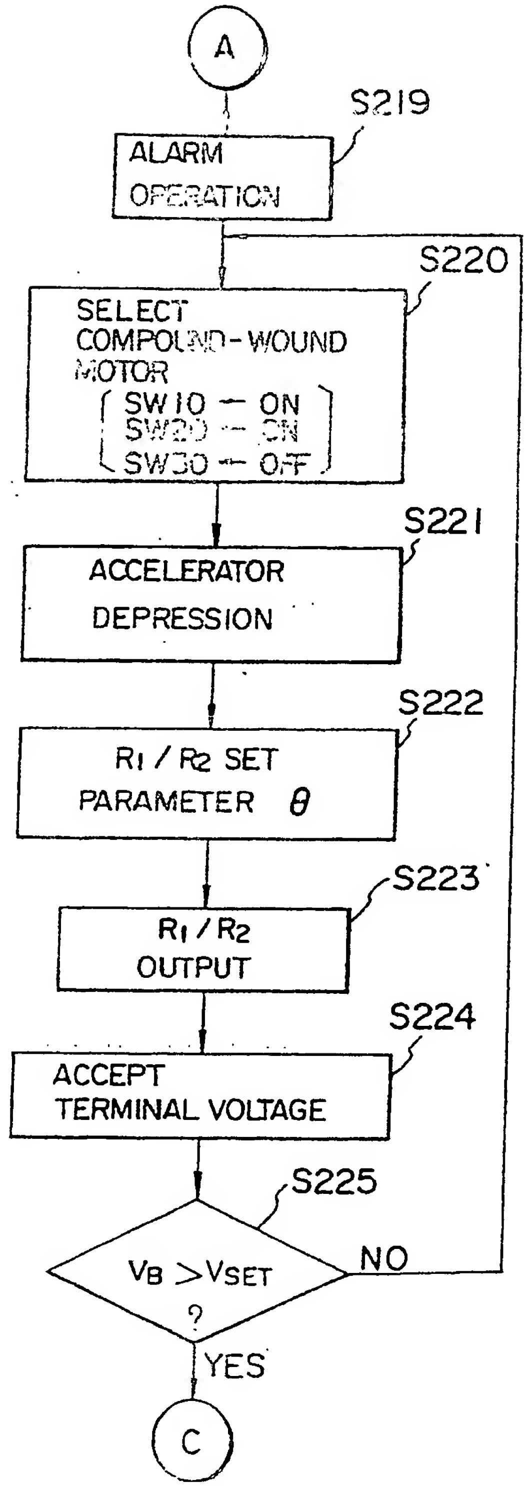

A
S219
ALARM
OPERATION
S220
SELECT
COMPOUND-WOUND
MOTOR
SW10 ← ON
SW20 ← ON
SW30 ← OFF
S221
ACCELERATOR
DEPRESSION
S222
R1 / R2 SET
PARAMETER θ
S223
R1 / R2
OUTPUT
S224
ACCEPT
TERMINAL VOLTAGE
S225
VB > VSET
?
NO
YES
C

FIG. 14

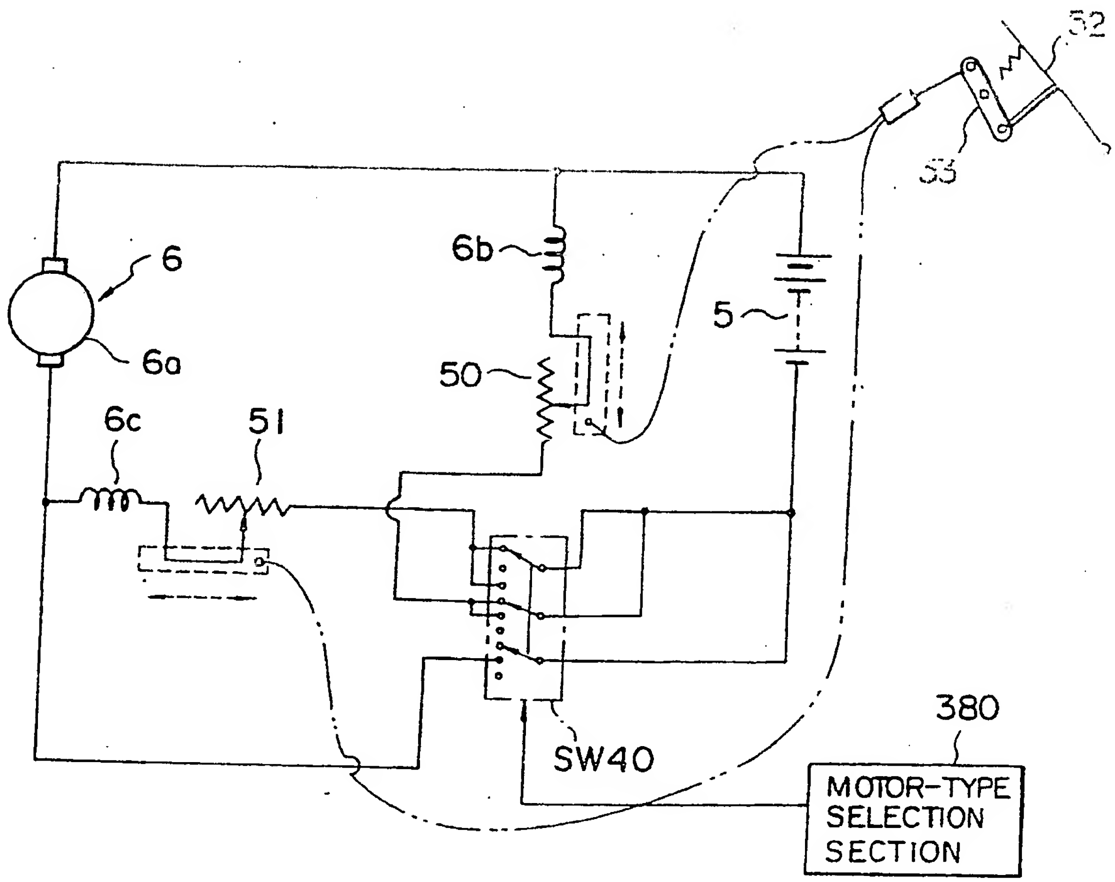


FIG. 15